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SUMMARY OF AN INTEGRATED ERTS-1 PROJECT AND ITS RESULTS AT THE MISSOURI GEOLOGICAL SURVEY*

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ABSTRACT

The aims of the Missouri Geological Survey ERTS-1 project have shifted significantly since its original inception. Initially, the nonfunded study was to evaluate environmental and geologic engineering parameters along the St. Louis to Kansas City Corridor from ERTS imagery. However, normal work loads took precedence and problems developed in budgeting time. Though the corridor study suffered, utilization of both ERTS-1 imagery and NASA-supplied aerial photography provided a significant impetus to a number of other Survey projects.

Use of the imagery involved the recognition and interpretation of various ground patterns. Analysis and application are tied to ongoing programs. Specific studies utilizing the imagery and NASA aircraft photography are: a statewide lake and dam inventory; assessment of flooding and floodprone areas along the Missouri portion of the Mississippi and Missouri Rivers; land-use classification for several counties; structural features in selected areas, and Pleistocene features in northern Missouri.

Though it has been suggested that repetitive coverage is not necessary for geologic studies, it is this specific feature along with the synoptic view of large portions of the State that provided the potential for the utilization of the ERTS imagery in Missouri. Other State agencies, Departments of Conservation, Agriculture, and Community Affairs, have expressed interest in the potential application of ERTS data in their respective fields.

INTRODUCTION

Unlike funded projects which are tied directly to a specific subject, a diversified, nonfunded program has evolved within the Missouri Geological Survey. ERTS imagery and NASA photography are being used in 10 active Survey programs and 11 projects that are underway or have been completed by sister-state agencies, industry, or the federal government. A direct outgrowth of this interest in remote sensing has been the establishment by the Governor of a committee on Technical Data Sharing. The committee has the responsibility of making recommendations at the State government level on acquisition and use of remote sensing data.

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This report is a compilation of the significant geologic features defined on the ERTS-1 imagery. Many of the features shown have been previously described (Allen, Martin, and Rath, 1973, and Martin, Allen, and Rath, 1973).

Study of the imagery to date has been restricted to visual examination of the bulk product, both positives and negatives. False color infrared and color enhanced images are prepared from the bulk product on color diazochrome film. The method is simple, fast, and inexpensive -- exposed under a sun lamp and developed in a wide-mouth jar. The resulting product can be used directly or photographed for slides. Because of the varying densities found in the positive transparencies, it is necessary to experiment with exposure times in making the diazo enhancements.

DEVELOPMENT OF THE PRESENT ERTS-1 PROGRAM

The ERTS-1 investigation at the Missouri Geological Survey has changed completely both in aim and personnel from the original proposal. The initial study, to apply imagery data to urban and engineering geology problems along the St. Louis-Kansas City Corridor, did not develop. Two problems became apparent. One, most of the anticipated goals could not be realized from detail available on the imagery and two, the normal work load did not permit time for the project.

Examination of selected frames by the Mineral Resource and Areal Geology Sections of the Survey led to their use in several ongoing programs. This resulted in rather wide interest and utilization of the imagery both within the Survey as well as other State agencies. An outgrowth was the presentation at the NASA-sponsored second ERTS symposium, March 3-5, 1973 (First-Look Analysis of the Geologic Ground Patterns on ERTS-1 Imagery of Missouri, Allen, Martin, and Rath) and a paper presented at the American Society of Photogrammetry Remote Sensing Symposium October 29 - November 1, 1973 (Geologic Ground and Drainage Patterns from ERTS-1 Imagery of Northern Missouri, Martin, Allen, and Rath).

It was realized by mid-summer, 1973, that a revised program must be submitted to NASA if the Survey was to continue as an ERTS-1 investigator. This was done, accepted by NASA, and in September, 1973, the four authors listed replaced the original investigators. The principal aim of the modified study is a statewide inventory of geologic-related ground patterns, particularly in those areas of active programs, and as a prelude to our ERTS-B proposal.

NASA-supplied data have provided input into the following: structure, stratigraphy, mineral resources Pleistocene studies, Precambrian studies, geomorphology, physiography, pedology, land-use inventory, flood assessment, and dam inventory.

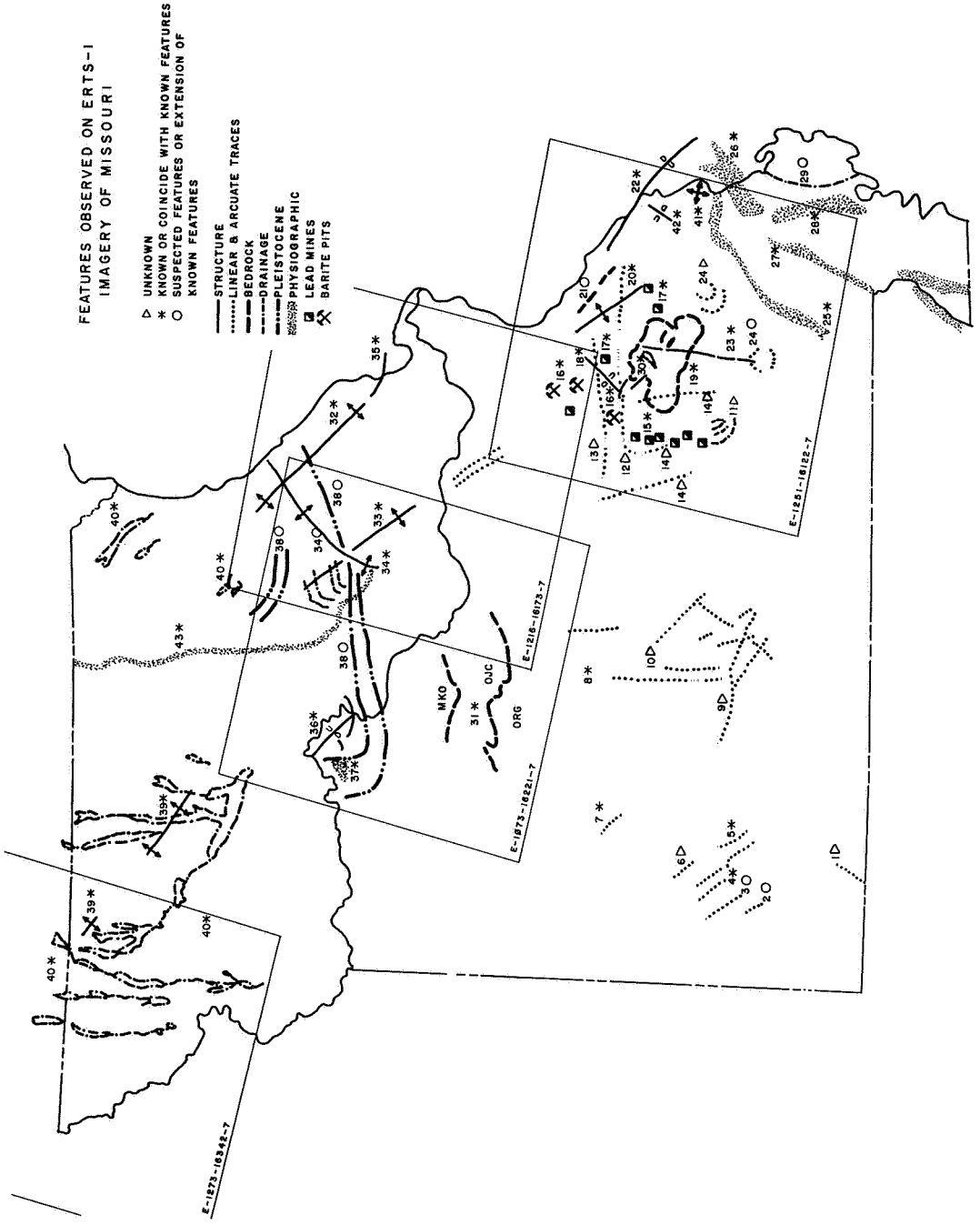
Three projects are summarized as examples of programs which utilize the ERTS and NASA aerial photography. These are followed by a listing and brief discussion of the ground patterns observed on the imagery of southwest, southeast, central and northwest Missouri.

PROJECTS UTILIZING ERTS AND OTHER NASA-SUPPLIED DATA

Dam Inventory: ERTS-1 imagery is being used in state-wide inventory of lakes and dams conducted by the Missouri Geological Survey for the Corps of Engineers in compliance with the 1972 National Dam Safety Act (PL 92-367). Lakes are transferred from the 9½" x 9½" Band 7 imagery to the 1:250,000 scale topographic maps and from this scale to the 7½' quadrangle map series. Magnification capability does not permit direct transferring from 1:1,000,000 imagery to 7½' quadrangle maps. Lakes of five to ten surface acres are plotted with certainty and those as small as two to five acres are identified with a fair degree of confidence. It is estimated that there are nearly 2,500 man-made lakes in Missouri. The ERTS imagery is playing a major role in determining lake locations, approximate surface acreages, greatly shortening the time required and keeping the inventory current.

Forest Inventory: Late in 1972, the Survey was contacted by the Forestry Division of the Missouri Department of Conservation on the feasibility of using ERTS imagery for forest mapping. We advised and assisted them on interpretation, provided imagery, and showed them the use of diazochrome transparency material. ERTS imagery was used in the determination of forest cover for 7 million acres in northwest Missouri and slides of the imagery were used by the Forestry Division at meetings with other state agencies to illustrate vegetation patterns as related to urban expansion. Coniferous forest cover can be distinguished from deciduous cover, but its recognition is dependent upon the time of year the image was recorded.

Flood Evaluation of the Missouri River, March-May 1973: Beginning March 10, 1973, flooding occurred on the Mississippi, Missouri and major tributary streams. For 9 weeks river level at St. Louis was above flood stage and four separate crests were recorded. Large areas of the Mississippi and Missouri River floodplains were inundated as the State experienced its longest flood of record. When it was realized flood period would be long ranging, a request was made to NASA/Goddard for U-2 or RB-57 coverage. On April 12, 1973, the Missouri River from Kansas City to St. Louis and the Mississippi River from St. Louis to the southern tip of the State was flown. The third and highest crest occurred on April 28th and 29th. Six days later on May 4, 1973, the Missouri Geological Survey underwrote a multispectral low altitude flight along the Missouri River from Boonville to St. Louis. The flight was made by the Kansas University Space Technology Center.


FEATURES OBSERVED ON ERTS-1
IMAGERY OF MISSOURI
△ UNKNOWN
* KNOWN OR COINCIDE WITH KNOWN FEATURES
○ SUSPECTED FEATURES OR EXTENSION OF KNOWN FEATURES
STRUCTURE
LINEAR & ARCUATE TRACES
BEDROCK
DRAINAGE
PLEISTOCENE
PHYSIOGRAPHIC
LEAD MINES
BARITE PITS
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E-1873-16321-7
E-1218-16173-7
E-1281-16122-7
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The Missouri River floodplain from Kansas City to St. Louis has been mapped to show areas flooded, areas of seep water, and major levee breaks. Comparison of the U-2 photos with the lower altitude photography shows the U-2 color infrared photography to be the more useful because of its greater areal coverage per frame and equal or better resolution. The larger areal coverage reduces evaluating time and allows for assessment of backwater along tributaries. The availability of this type data when needed emphasizes the importance of the NASA underflight program.

FEATURES OBSERVED ON ERTS IMAGERY

The main coverage studied is that of the southeast, east-central and the northwest. The geologic setting ranges from Precambrian through Tertiary with thick recent alluvium in the southeast; Ordovician through Mississippian with thin Pleistocene till cover in the east-central; and Pennsylvanian with thick glacial till and loess cover in the northwest.

The figure is a compilation of the significant linear, arcuate and other features observed on the imagery. In the following listing, structure names are used where the ERTS trace coincides with a known feature. Only the major features in each area are discussed. McCracken, 1971, is the principal reference to geologic structures in the State.

Southwest Missouri: Most of the coverage for this area has been cloud-covered and only a brief examination has been made. Bedrock in the area on which ERTS traces are plotted is lower Ordovician dolomite and sandstone in the east and Mississippian limestone in the west. Linears 4, 5, 7, and 8 coincide with the Golden City-Miller anticline, the Chesapeake fault, Humansville anticline and the Decaturville cryptoexplosive structure,respectively. The other linears parallel or appear to be closely related to known structures.

Southeast Missouri: The majority of traces observed on the imagery of this area were described in Allen, Martin, and Rath, 1973. The principal mining areas, Barite District (16), Old Lead Belt (17), and the New Lead Belt or Viburnum Trand (16), are all quite apparent. Contrast in water reflectance aids in distinguishing tailings ponds from lakes. The major structural features that coincide with linears are the Ste. Genevieve fault system (22), the Big River fault (18), the Ironton fault (30), the Roselle lineament (23) and the Farmington Anticline (20). An almost E-W linear (12) appears on all coverage of the area. The trace roughly coincides with the postulated 38th Parallel Lineament of Heyl (1972) and others. Physiographic features prominent on all the coverage of the area are the Ozark Escarpment (25), Benton Hills (26), and the Sikeston Ridge (28). Crowley's Ridge (27) is prominent only on the "wet-weather" imagery. False color IR diazochrome of wintertime coverage highlights the outline of the igneous core (19) of the St. Francois Mountains. Three major soil classifications were distinguished on the

imagery of the southeast Missouri "Bootheel", an area of thick alluvium. Soil types delineated are sand, clay loam and silt loam. Separation was based mainly on drainage characteristics and the boundaries compare favorably with available soil maps.

Central Missouri: Three traces seen on most of the coverage of this area coincide in part with known structures -- Lincoln fold (32), Mineola structure (33) and the Mexico anticline (34). The Mexico and Mineola traces extend well beyond the known limits of these structures. Arcuate traces (38) are quite prominent on imagery of this area and are thought to represent or be related to early Pleistocene recessional moraines. These features are important to a better understanding of the Pleistocene history in Missouri. Bedrock boundaries (31) are enhanced on the imagery by changes in vegetation, soil, rock types and topography.

Northwest Missouri: The greater part of northern Missouri is blanketed by glacial drift ranging upwards to 400 feet. Bedrock exposures are quite limited. In addition to the present drainage system developed mostly on drift, there is a buried system developed entirely on bedrock and filled with sand, gravel and till. Stream patterns in this part of the State were rather indistinct on the early coverage. However, imagery made last spring and early summer, a period of heavy rainfall, was quite striking in that it gave the regional drainage an overall "chain-of-lakes" (40) appearance.

Wide floodplains are present where streams flow on drift; narrow segments are where flow is across bedrock highs resulting from thinning of drift, topographic highs on the bedrock surface, and regional structure. "Moisture-damming" takes place at these constrictions. Soil moisture accentuates the wide portions of the floodplain and appears to increase where the two drainage systems are superimposed.

Although glacial drift ranges upwards to several hundred feet in this area, a faint linear trace (39) on the imagery coincides with one of the known anticlinal structures.

CONCLUSION

1. The variety of ERTS traces that coincide with known geologic features establishes the position of satellite imagery as a major reconnaissance tool.

2. Identification of ground patterns in a known setting is an important aid in the analysis of an unmapped area.

3. The repetitive coverage and wide synoptic view provided by the imagery are in themselves major enhancement features. Repetitive coverage was found to be a must for most geologic evaluations.

4. The number of geologic features identified on imagery of a mid-western setting shows its use in geologic studies is not limited to mountainous, arid, or barren shield terrain.

5. The use of satellite and high altitude imagery and photography provided by the NASA ERTS-1 program is being utilized by several state agencies and a Governor's committee is presently working to familiarize state government with the potential application of remote sensing data.

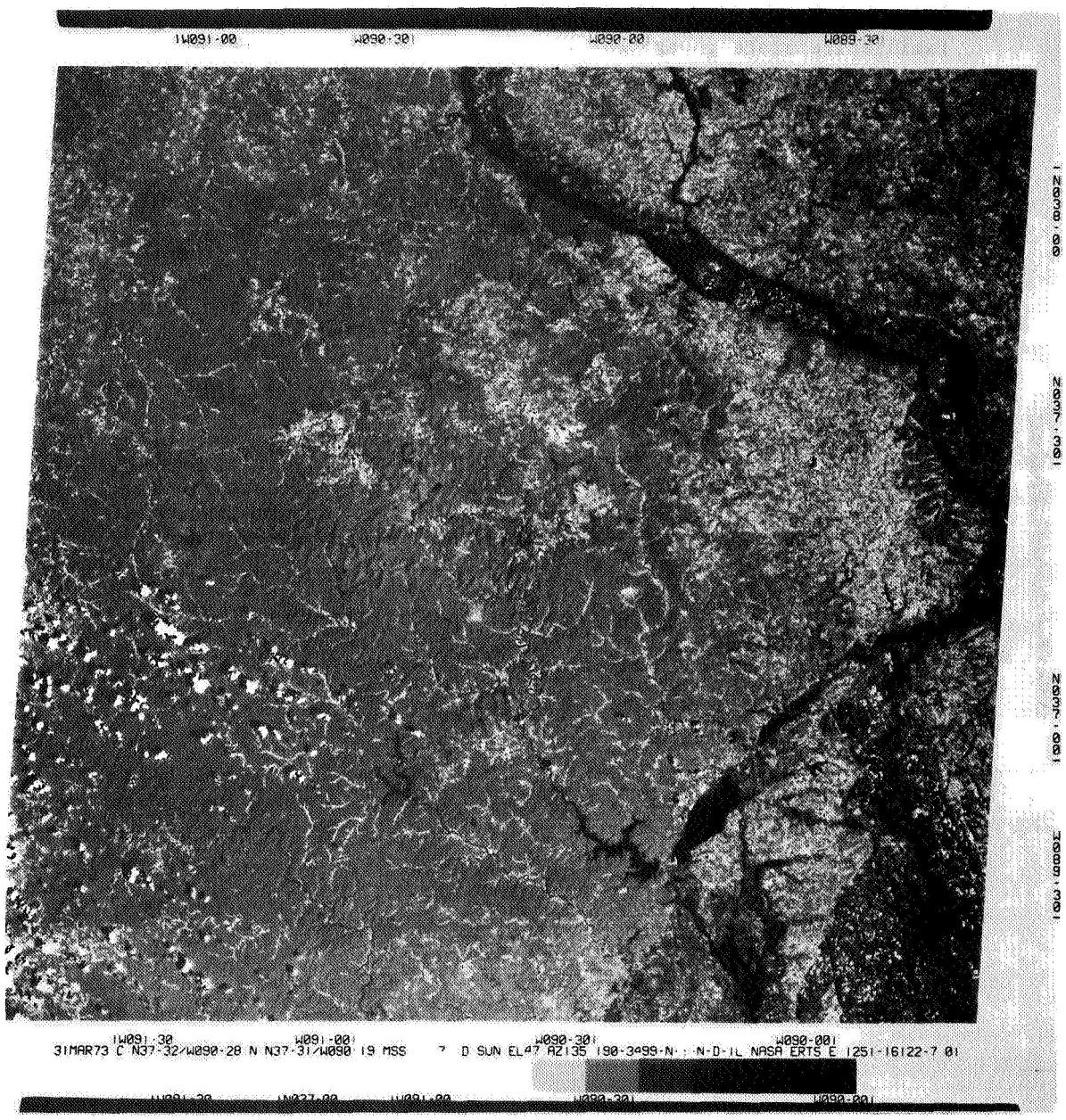
REFERENCES

Allen, William H., Martin, James A. and Rath, David L., 1973, First-look analysis of geologic ground patterns on ERTS-1 imagery of Missouri: in symposium on significant results obtained from the earth resources technology satellite-1, v. I: Technical Presentations Section A, NASA/Scientific and Technical Information Office, Washington, D. C.

Heyl, Allen V., 1972, The 38th parallel lineament and its relationship to ore deposits: Econ. Geology, v. 67, p. 879-894.

Martin, James A., Allen, William H. and Rath, David L., 1973, Geologic ground and drainage patterns from ERTS-1 imagery of northern Missouri: in Symposium proceedings on management and utilization of remote sensing data, American Society of Photogrammetry, Falls Church, Virginia.

McCracken, Mary H., 1971, Structural features of Missouri: Mo. Geol. Survey Rept. Inv. 49.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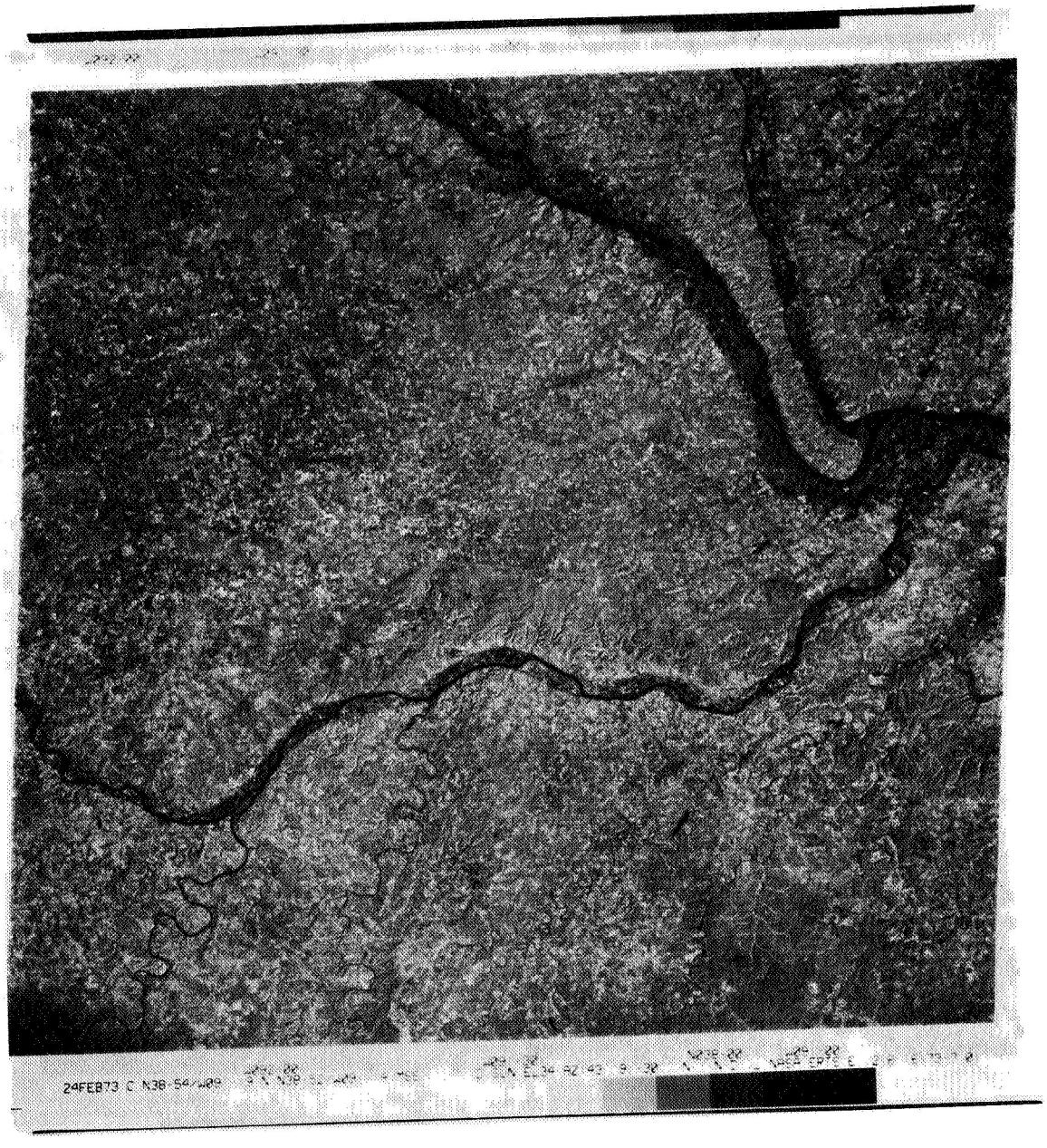

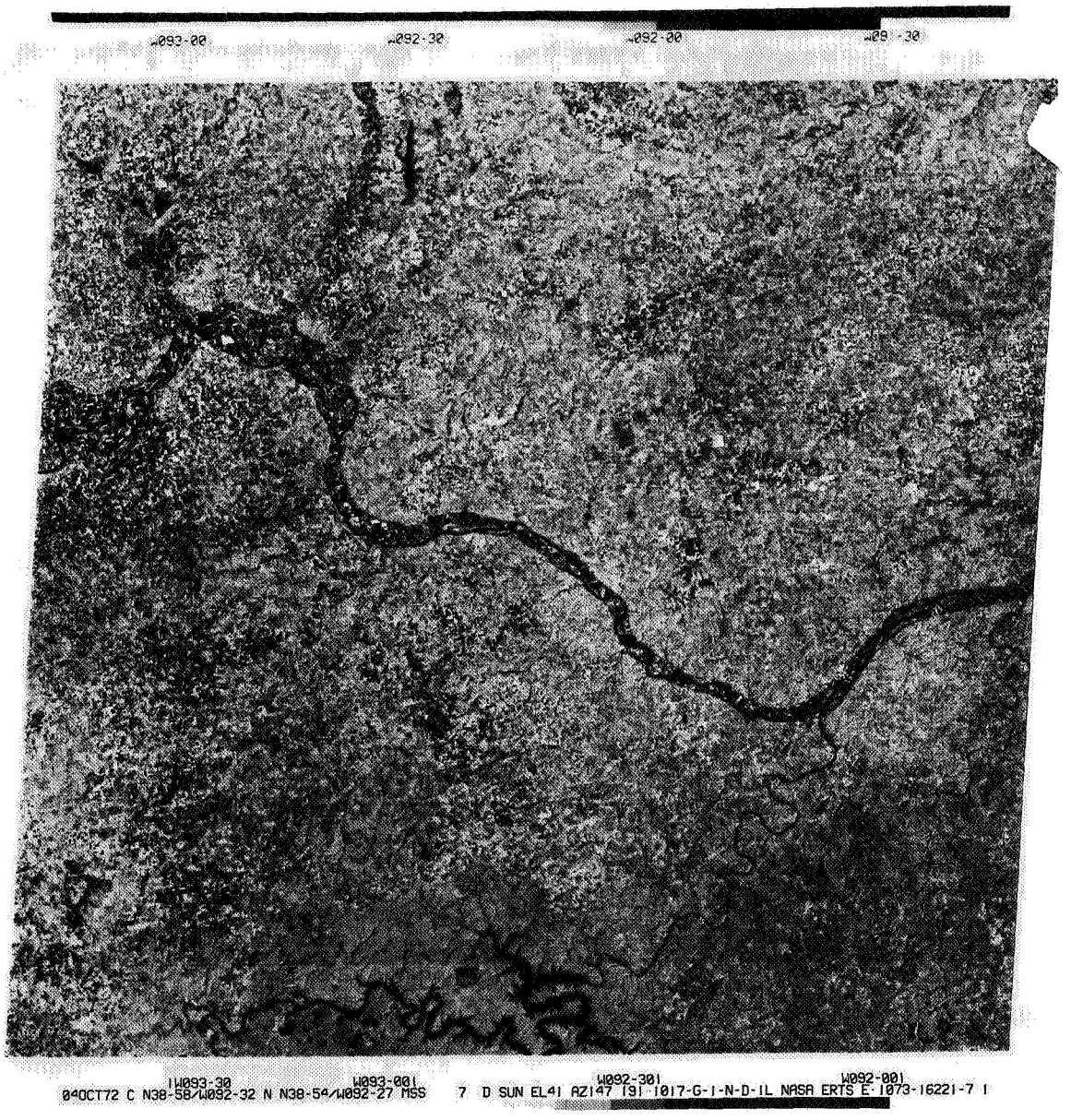
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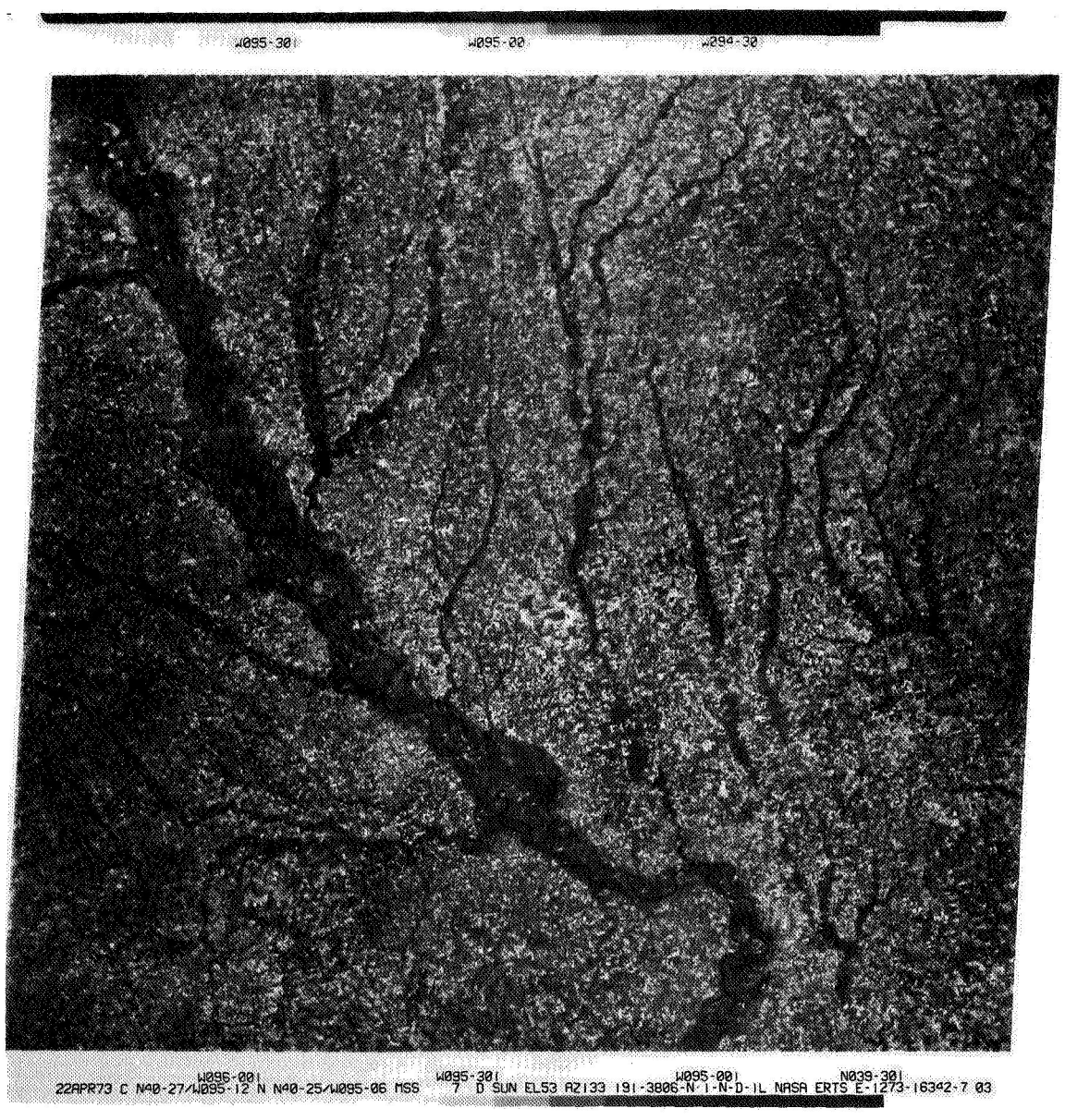
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